









**Device for a temporary connection, especially for the appendix of an artificial satellite and process of opening this connection.**

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**Report a data error here****Abstract of EP0402263**

In order to temporarily link two elements such as an appendix of an artificial satellite and the body of this satellite, a device is used which comprises a holding mechanism (22) of any structure whatever and a freeing member (20) made of a material with a memory of shape. The holding mechanism (22) normally applies a mechanical holding tension between the elements. When it is desired to free these elements, the freeing member (20) is heated for example by means of a heating resistor (28) or by using the solar energy, until the temperature of transformation of the material with a memory of shape is reached. The arrangement of the freeing member (20) is such that its change of shape has the effect of removing the mechanical holding tension and of creating a play between the elements.

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### TEMPORARY DEVICE OF CONNECTION, IN PARTICULAR FOR APPENDIX OF ARTIFICIAL SATELLITE, AND PROCEEDED OF RELEASE OF SUCH a CONNECTION

The invention relates to a device making it possible to connect several elements in a temporary way, as well as a process of release of these elements.

This device and this process are particularly adapted to be used in the space field, for example on artificial satellites and orbiting stations, on which are fixed in a provisional way of the subsystems or the equipment such as antennas or solar panels which must be released after the placing in orbit.

The devices of temporary connection used in the space field include/understand usually a mechanism of maintenance which ensures, before and during the placing in orbit, the connection between the appendix and the body of the satellite. For this purpose, this mechanism applies between the two elements a mechanical tension of maintenance. According to cases, this mechanism is made up either by a metal tie or in ?Kevlar? (trade mark), or by a tilting clamp articulated, for example, on the appendix fixed on the satellite.

The devices of temporary connection include/understand also means of release of the mechanism of maintenance.

In the large majority of the cases, these means of release include/understand pyrotechnical components. In particular, of the shears pyrotechnics are usually associated the metal ties to order the rupture of it. In the same way, the tilting clamps, are maintained in place against the action of a spring by a mechanism of locking whose release is ordered either while cutting a stem of this méca nism by means of a shear pyrotechnics, or by a cable actuated by a pyromecanism and simultaneously releasing the mechanisms of locking of several devices of connection.

In the case of the ties in ?Kevlar?, the means of release include/understand a resistance of heating surrounding the tie to order lengthening or fusion of it.

In these existing devices of temporary connection, the means of release used currently present all of the notable disadvantages.

Thus, the pyrotechnical components have an often constraining obstruction and a mass, and they induce shocks at the time of their implementation. Moreover, the pyrotechnical components must imperatively be tight, in order to avoid any pollution of the equipment embarked on the satellites, in particular when this equipment comprises optics. The pyrotechnical components also have as a disadvantage of having very limited operation ranges, with regard to the functional performances and the environments, which leads for each particular case either to the development of a new product, or with long and expensive complementary qualification tests. The high cost of these components thus limits the number of tests to the right need. Lastly, the nature of the pyrotechnical components imposes particular precautions at the time of their implementation and conduit, when an appendix is fixed in several points, to multiply of as much the number of pyrotechnical natures on the satellite.

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In addition, the mechanisms with tie in ?Kevlar? released by means of a resistance of heating are expensive and require an important electric power, in particular if it is necessary to obtain the fusion of the tie. Moreover, the fusion of the Kevlar can involve a nonacceptable pollution for the close components, for example in the optical devices including/understanding of the mirrors or the lenses.

The invention precisely has as an aim a temporary device of connection comprising a mechanism of maintenance of an unspecified type and means of release of this mechanism not presenting the disadvantages of the pyrotechnical components and resistances of heating associated with ties in ?Kevlar?.

For this purpose, it is proposed a temporary device of connection several elements between them, including/understanding a mechanism of maintenance ready to apply between the aforementioned elements a mechanical tension of maintenance, and means of release whose actuation causes to remove the aforementioned mechanical tension and to create a play authorizing a relative movement between the elements, characterized by the fact that the means of release include/understand a body of release realized in a material with memory of form and cooperating with the mechanism of maintenance.

The use of a body of release in a material with memory of form allows, by heating this body beyond temperature of structure transformation of material, to modify the form and/or dimensions of them.

If the mechanism of maintenance includes/understands a tie, the change in form of the body of release can be used to order a lengthening of this tie, or even its rupture, if one envisages on the tie a zone of less resistance.

When the mechanism of maintenance includes/understands a tilting clamp, the change in form of the body of release can be used to release the mechanism of locking associated with this clamp, for example by lengthening a stem of the

mechanism of locking, until its rupture.

One is reminded that a material with memory of form is a material which presents two stable crystalline phases, respectively austenitic and martensitic, according to whether its temperature is higher or lower than the temperature of structure transformation characteristic of this material. When the material in martensitic phase is subjected to a mechanical constraint, it is deformed plastically and preserves this deformation as long as the temperature remains lower than its temperature of structure transformation. As soon as the temperature becomes higher than this threshold, the structure becomes again austenitic and the material regains its initial shape.

The use of a body of release in a material with memory of form has many advantages compared to the current techniques.

Thus, since the release is generated by a physical phenomenon, reliability is total. Moreover, one body of release thus realized makes it possible to remove the shocks and to be free from the problems of pollution raised by the use of pyrotechnical components. Moreover, the use of a material with memory of form makes it possible to adapt the performances mechanical (effort, etc) with the requirements while acting on dimensions for the body for release, while reducing the mass, the obstruction and the price compared to the existing techniques. If necessary, a mechanical redundancy can be obtained simply while placing in series or parallel two bodies of release in a material with memory of form. Lastly, reheating making it possible to carry out the change of state of material can not be obtained by the electric power of the satellite, but by using solar energy by an adequate orientation of the satellite, which simplifies the means of implementation (wiring, etc) and interfaces.

The invention also has as an aim a process of release of elements dependent between them by a mechanism of maintenance applying between the aforementioned elements a mechanical tension of maintenance, characterized by the fact that it consists in heating a body of release realized in a material with memory of form beyond of a temperature of phase shift of this material, this body of release cooperating with the mechanism of maintenance to remove the aforementioned mechanical tension then and to create a play authorizing a relative movement between the elements.

A mode of realization preferred of the invention, as well as an alternative of this mode of realization, now will be described while referring to the annexed drawings, in which: - figure 1 is a longitudinal cross-section of a device of temporary connection in conformity with the invention; - figure 2 is a sight on a large scale of the device of figure 1, illustrating the implementation of the means of release; - the figure 2A very schematically illustrates the release of an appendix of satellite fixed by three devices as illustrated on figures 1 and 2; and - figures 3 and 4 are longitudinal cross-sections representing an alternative of the temporary device of connection of figures 1 and 2, respectively in position of connection and during the release.

On figure 1, reference 10 indicates the body of an artificial satellite, or another spacecraft such as an orbiting station.

At the places or appendices such as antennas or solar panels must be fixed temporarily at the time of the setting on orbit, for example before their deployment, of feet 12 are fixed on body 10, for example by means of screw 14.

At the end of each foot 12 is placed a temporary device of connection 16 in conformity with the invention. Each device 16 allows, during the launching and until the moment of the release (for example after the placing in orbit), to maintain fixedly an appendix 18, several devices being able to be used to maintain the same appendix, like illustrates it the figure 2A.

Each device of temporary connection 16 is composed of a mechanism of maintenance with which cooperate of the means of release including/understanding a body of release 20 realized, in accordance with the invention, in a material with memory of form.

In the mode of realization represented on figures 1 and 2, the mechanism of maintenance includes/understands a stem of connection consisted a screw 22 whose threaded end 22a is screwed in a tapped hole 23 formed in a cylindrical end 12a of the foot 12, and whose head 22b is resting against a leg 18a of appendix 18, via a disc 24 and of a spacing sleeve 26.

In a more precise way, the leg 18a comprises a laterally open hole 18b, in which is committed the cylindrical end 12a foot 12. When the screw 22 is tight, the leg 18a is in a hurry with a mechanical tension of maintenance corresponding to the tightening of the screw, between the head 22b of the latter and a shoulder 12b formed on foot 12, at the base of the cylindrical end 12a, via the disc 24 and of the spacing sleeve 26. Under these conditions, appendix 18 is connected firmly to body 10 of the satellite.

In the mode of realization of figures 1 and 2, the body of release 20 with the shape of a spacing sleeve which is laid out around the screw 22, inside the spacing sleeve 26, so that its ends are respectively in support under the disc 24 and on the face of 12c end of the cylindrical end 12a of foot 12. The expression ?in support? used here does not exclude that a light play, necessary to ensure the isostatism of the connection, can exist between spacer 20 out of memory-shape alloy and the remainder of the assembly, under the conditions illustrated on figure 1 which correspond if the temperature is lower than the temperature of transformation of memory-shape alloy in which this spacer 20 is produced.

For the realization of the spacing sleeve 20, one chooses a memory-shape alloy suitable, according to the conditions of use, by taking account in particular of the temperature of phase shift of alloy. In a way by no means restrictive, one will quote among materials with memory of form usable in the invention alloys containing iron (Fe-C, Fe-Cr, Fe-Ni...), of copper alloys or metals noble (Cu-Zn, Cu-Sn, Cu-Al, Cu-Zn-Al, Cu-Zn-Al-Nor, Cu-Al-Ni, Ag-Cd, With-Cd...), of alloys containing titanium and/or nickel (Ni-Ti, Nor-Ti-Fe, Ni-Al...) and certain pure metals (Co, Ti, Na).

In the mode of realization illustrated on figures 1 and 2, the heating of the spacing sleeve 20 out of material with memory of form until the temperature of transformation of this material is obtained by means of a device of heating made up, for example, by an electric resistance 28 placed directly around spacer 20. Electric drivers 30 make it possible to connect this electric resistance 28 to an electric power source (not represented) embarked on the satellite, via a switch (not represented) open during launching.

When an order of closing of this interruptor is emitted, spacer 20 out of material with memory of form is heated until a temperature higher than its temperature of structure transformation. The structure of this material thus becomes again austenitic, which causes to make him regain its initial shape which, in this case, corresponds to a bigger length of spacer 20.

As famous figure 2, an adequate dimensioning of the components of the assembly combined with the use of a relatively malleable material for the screw 22 cause, during the lengthening of spacer 20, to lengthen the screw 22 between its head 22b and its threaded end 22a. This lengthening is sufficient to remove the mechanical tension of maintenance applied initially to the leg 18a by the screw 22 and to create a play  $J1 + J2$  in the assembly initially binding the leg 18a to foot 12. Since the hole 18b is laterally open, appendix 18 is thus released, like illustrates it very schematically the figure 2A.

In an alternative of realization not represented, the heating of material with memory of form is obtained without using the electric power of the satellite, by directing this last after its placing in orbit, so that the material is then heated by solar energy.

In another alternative of realization illustrated on figures 3 and 4, the fitting general of the assembly is the same one as that which has been just described while referring on figures 1 and 2, so that the identical or similar bodies, which are indicated to facilitate comprehension by the same figures of reference increased by 100, are not described again.

In this alternative of realization, the hole 118b formed in the leg 118a is a cylindrical hole which does not emerge laterally. So that the lengthening of the tubular sleeve 120 out of material with memory of form, consecutive with its heating by heating resistance 128, releases appendix 118, it is thus necessary that this lengthening leads to the break of screw 122. For this purpose, the latter presents in this case a zone of less resistance, formed for example by machining a throat 122d in its part located inside sleeve 120.

As famous figure 4, the lengthening of sleeve 120 resulting from its heating then causes the break of screw 122 on the level of the throat 122d and, consequently, the release of appendix 118.

Of course, the invention is not limited to the modes of realization which have been just described as examples, but covers all the alternatives with them. One will observe in particular that the body of material release with memory of form can take forms very different from the tubular sleeve described, for example to adapt to mechanisms of maintenance of different structures such as mechanisms with tilting clamp. In this last case, the body of release can, for example, to take the shape of a hook locking the clamp in position of connection during the launching and whose consecutive change in form to the phase shift of material with memory of form releases the clamp automatically.



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1. Temporary device of connection several elements between them, including/understanding a mechanism of maintenance (22) ready to apply between the aforementioned elements a mechanical tension of maintenance, and means of release (20) whose actuation causes to remove the aforementioned mechanical tension and to create a play authorizing a relative movement between the elements, characterized by the fact that the means of release include/understand a body of release (20) realized in a material with memory of form and cooperating with the mechanism of maintenance (22).
2. Device according to claim 1, characterized by the fact that the means of release include/understand moreover of the means of heating (28) located near the known as body of release (20).
3. Device according to any of the claims 1 and 2, characterized by the fact that the mechanism of maintenance includes/understands a stem of connection (22) normally presenting a length such as the aforementioned mechanical tension is applied between the aforementioned elements, the aforementioned body of release (20) being arranged in order to cause a predetermined lengthening of the stem of connection when the temperature of the body of release exceeds a temperature of phase shift of the aforesaid material with memory of form.
4. Device according to claim 3, characterized by the fact that the body of release to the shape of a spacing sleeve (20) surrounding the aforementioned stem of connection, and interposed between a bearing surface formed on first of the aforesaid elements and a bearing surface formed on a first end of the aforesaid the stem of connection (22).
5. Device according to claim 4, characterized by the fact that the stem of connection (22) comprises a second threaded end (22a) screwed in the first element and crosses a projecting part (18a) of the second element, in order to normally press with the aforementioned mechanical tension this projecting part between the bearing surface (12c) formed on the first end of the stem of connection and another bearing surface formed on the first element.
6. Device according to claim 5, characterized by the fact that the projecting part of the second element is shifted axially on the stem of connection (22), a spacing sleeve (26) laid out around the body of release (20) being interposed between the aforementioned projecting part and the bearing surface formed on the first end of the stem of connection.
7. Device according to any of claims 3 to 6, characterized by the fact that the stem of connection (122) presents a zone of less resistance (122d) ready to break at the time of the aforesaid predetermined lengthening of the stem of connection.
8. Device according to any of the preceding claims, characterized by the fact that the aforementioned elements include/understand a body of satellite (10) and an appendix (18) having to be released after placing in orbit of this satellite.
9. Proceeded of release of elements dependent between them by a mechanism of maintenance (22) applying between the aforementioned elements a mechanical tension of maintenance, characterized by the fact that it consists in heating a body of release (20) realized in a material with memory of form beyond of a temperature of phase shift of this material, this body of release cooperating with the mechanism of maintenance to remove the aforementioned mechanical tension then and to create a play authorizing a relative movement between the elements.
10. Process according to claim 9, caracté small channel by the fact that one heats the aforementioned body of release (20) by means of solar energy.
11. Process according to claim 9, characterized by the fact that one heats the aforementioned body of release (20) by a means of heating (28) located near this body.

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